A Study of a Wireless Smart Sensor Platform for Practical Training

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Abstract. In order to overcome the obstacles in traditional experimenting and practical training courses, as well as in enhancing the functions of the present e-learning system, the study took sensor network technology as the foundation in developing a web services system. The system will be able to make presentations of the students 'operations and results on an immediate basis, allowing the students to be guided adequately as they face problems during experiment and practical training.

1 Introduction

With recent advances in micro-electro-mechanical systems (MEMS) and wireless communication technologies, wireless sensor networks have been produced out of laboratories and transforming our lives. Wireless sensor networks are more attractive and useful than traditional wired sensing systems for their ad-hoc and easy deployment. This new technology expands our sensing capabilities by connecting the physical world to the communication networks and enables a broad range of applications (Akyildiz, Su, Sankarasubramaniam, and Cayirci, 2002). Sensor networks are the integration of sensor techniques, distributed computation, and wireless communication techniques. The network can be embedded in our physical environment and used for sensing, collecting data, processing information of monitored objects, and transferring the processed information to users. The architecture of the sensor node's hardware consists of five components: the sensing hardware, the processor, the memory, the power supply, and the transceiver (Tubaishat, Madria, 2003). For many applications, a sensor network operates in three phases. In the first phase, sensors take measurements that form a snapshot of the signal field at a particular time. The measurements are stored locally. In the second phase, information retrieval takes place where data are collected from individual sensors. In the last phase is where information is processed in which data from sensors are processed centrally with a specific performance metric (Dong, Tong, and Sadler 2007). Such a network is composed of many tiny low-power nodes, with each consisting of actuators, sensing devices, a wireless transceiver, and possibly a

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mobilize (2002). These sensor nodes are massively deployed in a region of interest to gather and process environmental information. Meanwhile, ubiquitous (or mobile) technology and its applications have spawned an extensive programme of research because of the rapid growth in wireless sensor networks (Chan, Hwang, Yang, Chen, and Huang, 2009).

The higher capital cost of acquiring MEMS's equipment within each university presents a considerable financial challenge. Much time and cost are used in teaching these techniques. Particularly, computerized machines are continuously increasing in use. The development of educating engineers on computerized machines becomes much more difficult than on traditional machines, and this is because of the limitation of the extremely expensive cost of teaching; the quality and quantity of teaching cannot always be promoted in this respect since the traditional teaching methods do not respond well to the needs of the future. Most of technology education relies on "cookbook"-oriented experiments that provide students with a technical question, the procedure to address the question, the expected results of the experiment, and even an interpretation of those results. By contrast, self-directed learning is to encourage students to learn inductively with the help of teaching systems. This method gives students more freedom to come up with their own questions to investigate, devise an experimental procedure, and decide on their own terms for how to interpret the results. Long pointed out that there are at least six kinds of cognitive skills appear to be particularly important in successful self-directed learning, and they are goal setting skills, processing skills, other cognitive skills, some competence or aptitude in the topic or a closely related area, decision making skills, and self-awareness. Effective, or successful, self -directed learning depends on information gathering, information monitoring, students' processing and other cognitive activities, and in the way they react to information. The evolution of computer and Internet technologies has made it easy to access learning contents from virtually anywhere, anytime, and at each individual user's own pace. Students make their own meaning of what they are learning by relying on mental models of the world. Using the user interaction data and direct questioning techniques, this intelligent tutor helps students understand complex technical phenomena by constructing mental models that reflect reality as perceived by acknowledged experts while minimizing models containing significant misconceptions (Miller et al., 1998; Shin et al., 2002).

Even though self-directed e-learning focuses on the independent learner who engages in education at his own pace and free from curricular obligations, the appropriate individual instructions are given by understanding the state of understanding of a student. The intelligent means of tutoring, i.e. the wireless sensor networks, provides information necessary in realizing appropriate tutoring (Matsubara et al., 2002). A number of tools, some purposefully and others serendipitously, have become key enablers of this learning paradigm. For example, tools such as Google Scholar, CiteSeer Research Index, etc. make it possible to conduct literature searches without stepping out of one's room (Desikan, DeLong, Beemanapalli, Bose, and Srivastava). The advance in the optical-fiber network makes real-time transmission of a large amount of data possible between two or more remote places (such as three-dimensional models or video images). In particular, by connecting virtual environments through the broadband network (Paquette, Ricciardi-Rigault, Paquin, Liegeois, Bleicher, 1996), a three-dimensional virtual world can be shared between remote places. The field oú virtual reality (VR) initially focused on immersive viewing via expensive equipment, rapidly expands and includes a growing variety of systems for interacting with 3D computer models in real-time (Sung & Ou, 2003). The various applications in the different fields including education, training, entertainment, medicine, and industry have been developing, while even more areas will gain benefits from using VR-enabled technoloogies (Craig, Sherman, 2003). In the past few years, a number of interactive VR systems have been developed, for instance, an educational virtual environment (Bouras, Philopoulos, Tsiatsos, 2001) is such a special case where the emphasis is more on education and collaboration than on simulation.

2 Development of Sensor Network Environment

The new technology of wireless sensor network allows sensing capabilities to be expanded by connecting the physical world to the communication networks existing in cyber space. In order to support self-directed learning in MEMS technology, many sensor devices need to be deployed in the laboratory to collect real-time information of students' motion and machine operation conditions. The Zigbee modules were used to build a wireless sensor network in this research. The proposed architecture of the sensor network system is shown in Figure 1. The overall system architecture consists of a Web camera, a Zigbee dongle (base node), a server, and wireless sensor nodes. The wireless sensor nodes consist of two key parts, referred to as the static and the mobile nodes. The static sensor nodes are scattered in the laboratory and they form a multi-hop mesh networking topology. A key role of the static node is to transfer all the data packets coming from the mobile node back to the dongle. The other key role of the static node is to provide a sufficient number of anchor points for the localization. Each of these sensor nodes has the capability of collecting data and routing data peer-to-peer to the Zigbee dongle. The Zigbee dongle is used to bridge the sensor network to the Internet in that it provides a serial interface and a wireless connection for node programming and data transfer. The server is connected to the Internet to enable remote users to access the laboratory monitoring system. The mobile node, comprised of an accelerometer worn by students, is for monitoring student motion and position in an indoor environment.

During the process of experiment and practice, the students almost always have the need to operate machines and adjust machining parameters manually, in addition , there are some machines also requiring students to step on pedals and have the machining parameters adjusted that way. Therefore, the study intends to incorporate ultra-thin force sensing unit (0.127mm) into a Zigbee node, making flexible force sensors, and then install handles and pedals. "Are students able to use tools correctly?" is the necessary matter of subject that needs to be discussed during experiment and practice. Therefore, the study plans to connect the Zigbee node with the PIR325 infrared sensing unit to make wireless infrared sensor and have it installed in the tool box. The Zigbee node will be connected with a three-axis micro electro-mechanical system (MEMS)-based accelerometer so that a wireless accelerometer can be created, which is a device measuring proper acceleration that will be available to detect the magnitude and the direction of the acceleration as a vector quantity. When the sensor is worn by the students, it can not only detect their motions inside the laboratory but also record their activities at the same time.

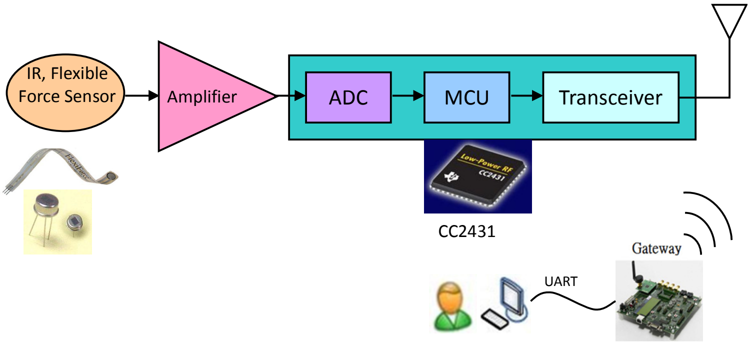

Fig. 1. Architecture of the wireless sensor system

3 Implementation

A graphical user interface (GUI) was designed for remote users to carry out the desired operations such as sending commands and parameters to drive the sensor nodes and visualizing the measurement results. The thesis use ASP.NET and Microsoft Visual C# to write an internet program in order to achieve the goal of quick and convenient processing of information. Figure 2 shows the Web GUI when a user is monitoring the laboratory environment at the remote client side. A remote user is able to adjust the view angle of camera to get required video data by clicking the mouse.

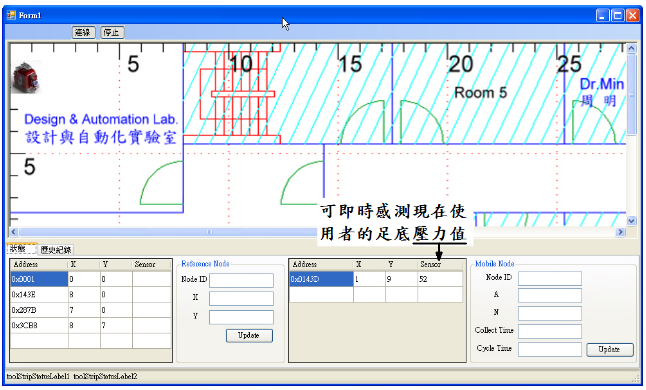

Fig. 2. Real time monitoring of force sensor at the remote client side

This interface accepts remote client side to get information about which node he or she wants to monitor by clicking on the buttons and the checkboxes on the panels. After that, clicking the sensor which has been installed on the node and observe the sensors' signal. The data of selected sensors are collected and sent to the Web GUI at fixed time intervals. In Figure 2, the down-left corner is the information measured by force sensor as time changes. In Figure 3, the down-left corner is the information measured by the IR sensor and as time changes, top-left corner shows the student's current motions in the laboratory.

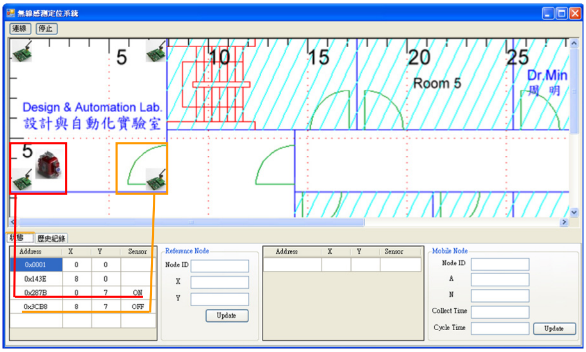

Fig. 3. Real time monitoring of IR sensor at the remote client side

4 Conclusions

Practical training is the important teaching strategy to improve students' industrial technology competence. Intelligent tutoring systems provide their own learning environment and place the student within it (Butz et al, 2006). The study uses sensor network technology to develop learning and teaching web services environment for industrial technology education that is ubiquitous in presence. The developed system was applied to the course of MENS manufacturing, and according to related data the teacher conveyed high satisfaction to the application of this system. Comparing to manufacturing course offered in the previous years, the average time of practical training for each student has been shortened considerably, and the usage of material has been lowered as well. This indicates that even when practicing in the clean room of a factory, the teacher is aware of problems faced by the students during the process of practice through the system developed by this research and can therefore appropriately provide the students with guidence to avoid mistakes from being made on a repeated basis.

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